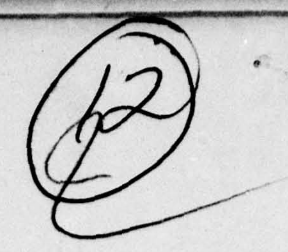
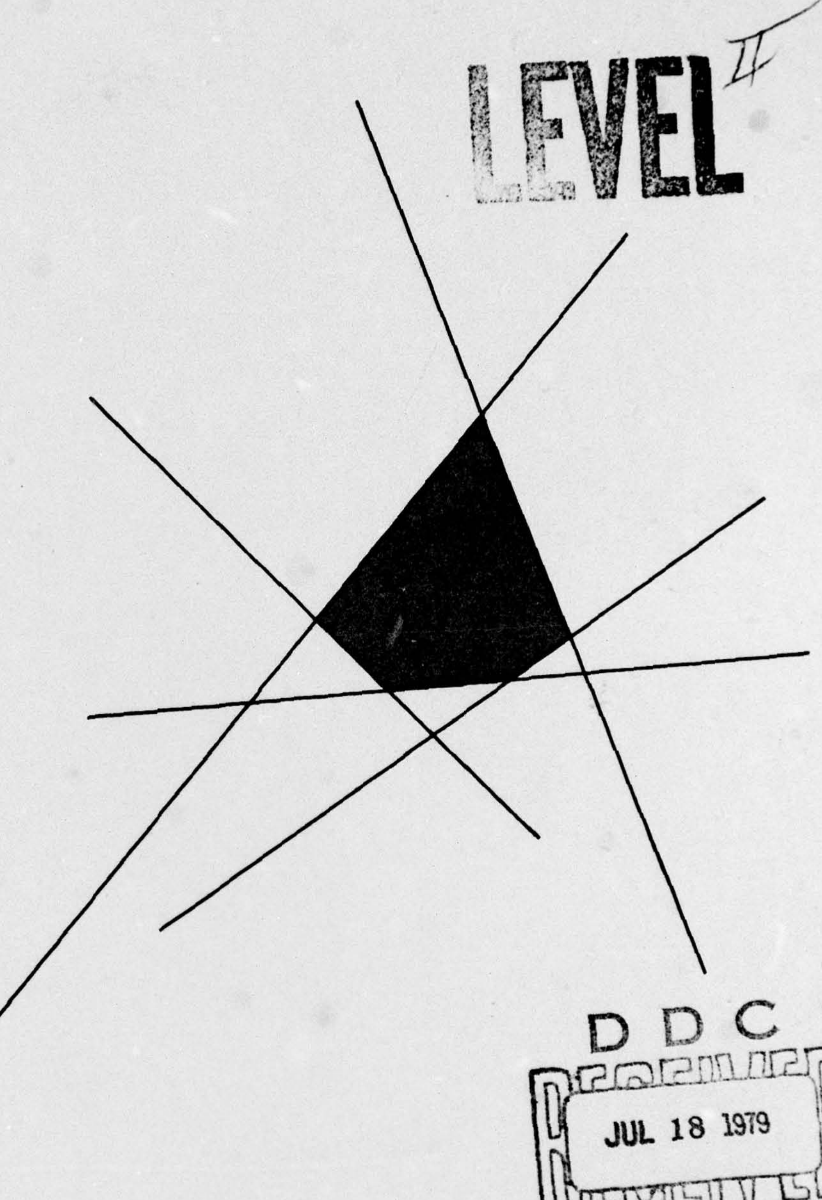

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by
HUBERT L. DREYFUS
and
STUART E. DREYFUS



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ABSTRACT

Except in unfamiliar circumstances, the highly skilled performer responds to holistically perceived situations with previously learned appropriate actions. The analytic mind is thus by-passed in the production of performance. We examine four possible roles of the by-passed analytic mind, and conclude that the highest level of masterful performance is achieved when the analytic mind is quiet and the performer is totally absorbed in his activity.

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THE PSYCHIC BOOM: FLYING BEYOND THE THOUGHT BARRIER

by

Hubert L. Dreyfus and Stuart E. Dreyfus

> A senior scientist [recently] noted that technology was passing man by. The operator could no longer process and input information fast enough to keep up with his onboard central processors ... . He could not react at the rates required by his systems [1].

> I ask students to stand at net in the volley position, and then set the machine to shoot balls at three-quarter speed ... . At first the balls seem too fast for them, but soon their responses quicken. Gradually I turn the machine to faster and faster speeds, and the volleyers become more concentrated. When they are responding quickly enough to hit the top-speed balls and believe they are at the peak of their concentration, I move the machine to midcourt, fifteen feet closer than before. At this point students will often lose some concentration as a degree of fear intrudes. "Relax your mind ... . Let it happen." Soon they are again able to meet the ball in front of them with the center of their rackets. There is no smile of self-satisfaction, merely total absorption in each moment. Afterward some players say that the ball seemed to slow down; others remark how weird it is to hit balls when you don't have time to think about it [2].

While man's technology, it seems, may be overtaking his capacity to *think*, it may not yet have even approached a skilled performer's ability to *act*. Such action faster than thought is not only a necessity when dealing with high-technology systems like that of the F-15, but even when there is time for thought the ultimate level of master performance is reached only by quieting the analytical mind.

This highest level of performance is reached by passing through a series of quite distinct stages.† The novice pilot fo-

†We have distinguished these stages in more detail and argued for their psychological reality in another paper [3].

cuses all attention on a list of memorized procedures to be applied in terms of specific context-free features which could be recognized by any objective observer. In doing so, he is so absorbed in details that he is unaware of surrounding events, and he experiences no sense of flying.

With further experience the trainee acquires the ability to recognize such situations as being in the landing envelope and such sensations as the accelerational forces, characteristic sounds and vibrations, and learns their importance. He analytically determines his actions by applying maxims such as "determine whether the aircraft is in the landing envelope" [4], return to base when vibrations are abnormal, etc. This intermediate student pilot begins to feel that he is flying the plane.

Finally, a pilot's repertoire of flying experiences becomes so extensive that each whole current situation is recognized as similar to a previous typical situation (paradigm),[†] and this previous situation elicits a remembered appropriate response. Furthermore, associated with each of these paradigms are other paradigms. Each of these associated paradigms are ones to which the original situation might typically be seen as similar should the salient aspects of the current situation not be what the current paradigm would lead one to expect. For example, suppose that the current situation is a normal landing, and hence location in the center of the landing envelope is a crucial aspect. If the

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[†]Psychologist Lee Brooks has experimentally shown that in certain situations subjects do, indeed, recognize patterns as similar to specific individual cases rather than as instances of a class defined in terms of necessary and sufficient features [5].

pilot perceives that he is very high in the landing envelope, the associated paradigm in terms of which he might see himself is a "go around" situation. The analytic mind has been completely by-passed in the production of performance and replaced by a holistic and intuitive mode of response. The pilot now has the experience that he is flying.

The same tri-partite phenomenon shows up whenever a person acquires a complex skill, be it highly intellectual like chess, or largely physical like tennis. For example, in chess a beginner learns simple rules involving context-free features, such as to trade pieces so as to maximize material balance (calculated by adding up the values of the individual pieces involved). In tennis, a player first learns context-free movements such as transferring his weight from one foot to the other while making a stroke.

With experience, a chess player learns to follow maxims such as "exploit a weakness on the king's side" or "avoid an unbalanced pawn structure." (There are, of course, no objective rules by means of which a novice could determine whether the pawn structure was unbalanced or the king's side weak.) And in tennis an experienced player may be advised to use top-spin on his lob.

When truly proficient, a chess master, immersed in the world of the game, immediately perceives the forces and tensions on the board as similar to those previously experienced in actual play or in the involved study of previous games. The highly skilled tennis player no longer thinks about using top-spin or applying other maxims, but, by-passing his analytical mind, he enters into the rhythm of the game [6].

Since we have already discussed this sequence of stages in detail in another paper, what interests us here is the various roles that the analytical mind, once it has been by-passed in the production of performance, can take vis-a-vis highly proficient activity.

In order to perfect the intuitive mind's paradigms, and in some cases even to improve its current performance, the analytical mind can review and improve the two associative functions of the paradigms. At the simplest level, it can assess how well the action associated with each paradigm enables the proficient performer to cope with each situation. For example, during air-to-air combat a highly proficient pilot's analytical mind might be assessing the appropriateness of maneuvers. If the analytical mind senses that the instantaneous intuitive responses are indeed appropriate, the pilot feels with euphoria that he is ahead of the plane. If inappropriate, there is uneasiness and the pilot feels that he is lagging behind the plane [7].

In this latter case, the analytical mind shifts to monitoring the second associative function of paradigms. Assuming an experienced performer with an adequate repertoire of appropriate paradigms, one reason a whole sequence of actions based on a series of paradigms can fail to cope adequately is that the associative function which replaces one paradigm by another when the former ceases to be appropriate needs improvement. Presumably, the intuitive mind, in moving from paradigm to paradigm, has gone down a path of association which has led to a current paradigm with an inappropriate associated action.

The intuitive mind is "locked into the wrong Gestalt." The job of the analytical mind is to get it out, and also to prevent this happening again.

To see what the analytical mind can do to get the intuitive mind back on the track, consider the following. If the intuitive mind is seeing the Necker cube in Figure 1 as a cube with vertex A in the nearest face and vertex B in the farthest face, the analytical mind can sometimes reverse the cube by focusing on vertex B . This makes vertex B salient, and the intuitive mind, if it is not hopelessly locked in the old Gestalt, will move the farthest face to the foreground, and the cube will reverse.

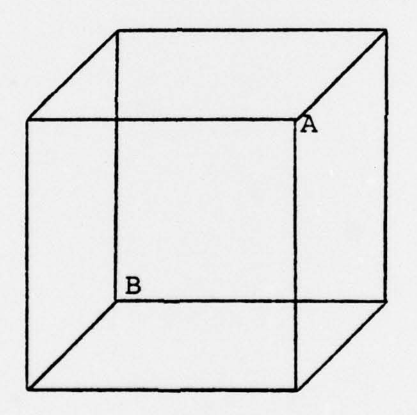


FIGURE 1

In general, when the intuitive mind is perseverating in what might be an inappropriate set, the analytical mind can focus its attention on aspects of the current situation which are inessential viewed under the current paradigm. The intuitive mind can then either ignore these aspects or it can see the situation in terms of

a different paradigm in which these aspects are crucial. Thus a pilot, in air-to-air combat with an adversary whom he deems to be of equal experience, may, after experiencing a sequence of actions as inappropriate, analytically entertain the hypothesis that his adversary is much less experienced than he supposed, and thus focus on aspects of the engagement he had not previously noticed. This may cause him to see events in a different light, and if his actions become more appropriate he will have learned to respond to such a possibility the next time he encounters a similar situation.

We have seen that there are two important types of *monitoring* functions performed by the analytical mind while the intuitive mind is engaged in the production of skilled performance: it can monitor the appropriateness of the actions to the situation and thereby improve performance in the future, or it can monitor the overall sense of the situation produced by the sequence of paradigms guiding the intuitive mind and can focus on aspects that the current paradigms lead the performer to overlook. We shall now see that the analytical mind can function in two other *nonmonitoring* modes. First, and most obviously, when the intuitive mind has completely taken over current skilled performance, the analytical mind is freed to engage in other tasks. Experienced drivers easily carry on conversations while still performing proficiently. In this mode there is probably no learning from experience, and whenever the unexpected occurs, one stops the unrelated analytical activity and focuses the entire mind upon the current situation. Second, masters of all skills experience moments of intense in-

volvement during which the analytical mind is completely quiet. There is no awareness of the passage of time and only after these moments are passed is there awareness of what has taken place.† This unselfconscious concentration occurs during moments of masterful intellectual activity†† and moments of peak performance of highly trained motor skills. No mental energy is allocated to monitoring. It is during these episodes that action is faster than thought.

These bursts of masterful performance at speeds faster than thought are not achieved without risk. To concentrate all of one's resources on performance one has to relinquish the monitoring function of the analytical mind, and thus run the risk of overlooking the true sense of the situation and blindly, albeit brilliantly, pursuing an inappropriate sequence of actions.††† In spite of the risk, pilots of the latest high-technology systems must be encour-

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†This phenomenon, according to Colonel Evan J. Griffith, occurs during crucial moments of air-to-air combat.

††We do not mean here, moments of creativity. We have no explanation of this ability to transcend all past experience.

†††A pilot faced with a sudden emergency should first respond instinctively and virtually instantaneously, but if this burst of unmonitored activity fails to cope with the crisis the analytical mind must intervene to question the pilot's original intuitive sense of the situation. If by calling attention to overlooked aspects the analytical mind can summon up a more appropriate paradigm, action faster than thought may again be possible. But if no paradigm is found, the analytical mind must take over the production of performance and use whatever propositional knowledge is relevant. Two recent examples of last-recourse analytical brilliance by commercial pilots are: (1) Jack McMahan's use of the unusual downward pitch known to be produced by the rear engine of a Lockheed 1011 to compensate for a system failure leading to uncontrollable climb [8] and (2) Harvey Gibson's use of the landing gear to slow the almost supersonic speed of a diving Boeing 727 [9].

aged to cultivate this spontaneous mode of response. They must learn that in moments of crisis the analytical process that in general permits learning and avoids mistakes must be transcended. For the very highest performance, they must unlearn the learning habits which first made their acquisition of proficiency possible.

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